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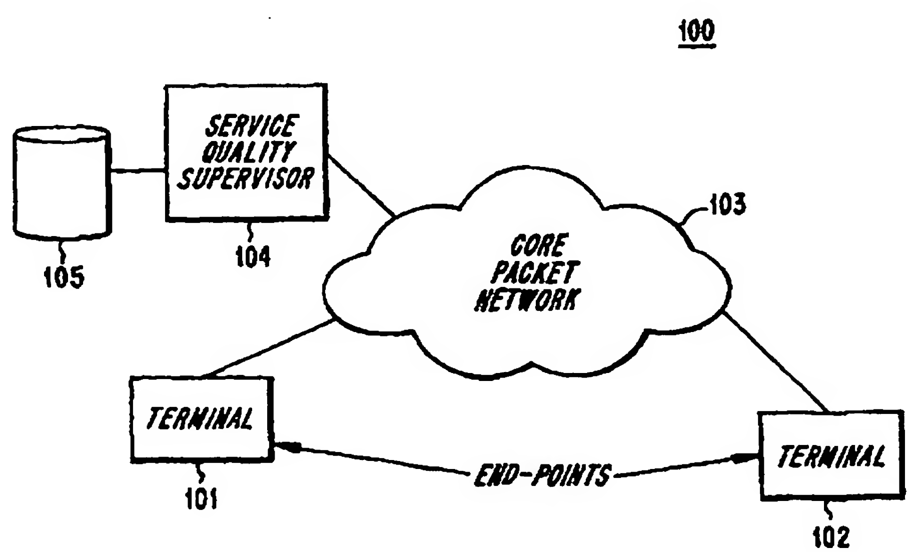

(57) Abstract

A method and system for improving the end–user quality of service in a packet switched network. Reports are sent from various nodes in the network informing a network supervisor of the end–user quality of service at the node, which represents an estimate of the quality from a human end–user's perspective. The quality supervisor analyzes the reports and sends commands to the node which sent the report and/or to other nodes in order to improve the end–user quality of service at the node and in the packet switched network as a whole. The nodes comprise sending and receiving terminals, routers and gateways. The reports include measurements of link parameters, device parameters and end–user quality of service.

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METHOD AND APPARATUS FOR IMPROVING END-USER QUALITY OF SERVICE IN PACKET SWITCHED NETWORKS

FIELD OF INVENTION

The present invention relates to packet switched telecommunications networks. More specifically, the present invention relates to improving overall packet switched network performance based on the quality of service as perceived by a human end-user.

BACKGROUND

With the evolution of the public switched telephone network (PSTN) society has come to expect close to 100% reliability in telephone connections. This expectation is due to the fact that the PSTN is a circuit switched network, wherein each user has a guaranteed bandwidth. However, it has been realized that the use of circuit switched communications for voice telephony wastes bandwidth, and thus leads to an increased cost. One way to lower the cost of providing telecommunications has been through the use of packet switching technology.

An example of a packet based telephony system, is described in ITU-T Recommendation H.323 "Visual Telephone Systems and Equipment for Local Area Network which Provide Non-Guaranteed Quality of Service", which is herein incorporated by reference. This recommendation has been selected as one of the standards for the transmission of voice over IP networks. The recommendation describes a system wherein the bandwidth cannot be guaranteed. In systems where bandwidth cannot be guaranteed, loss of voice packets and/or unacceptable transmission delays degrade the voice quality perceived by a human end user. Consequently, the quality of voice communications as perceived by a human end-user of a packet switched telecommunication system cannot be guaranteed by the system operator.

One technique for "quality of service" measurement which uses link parameters to determine the quality of a communication connection is described in European Patent Application number 0 786 883 A1 by Dollin et al. Dollin et al. describes a method for making "quality of service" measurements between two endpoints on an ATM network, wherein monitoring probes are connected to the communications links between the endpoints and the network. Dollin et al. uses the phrase measuring the "quality of service" as a synonym with measuring a set of link parameters (including delays and bandwidth).

A solution for measuring the quality of a speech service from a human end-user perspective using link parameters, in the field of radio cellular networks is described in Minde et al. U.S. Patent Application No. 08/861,563, "Speech Quality Measurement in Mobile Telecommunication Networks Based on Radio Link Parameters" filed on May 22, 1997, which is herein incorporated by reference. Minde et al. describes the use of radio link parameters in a statistical analysis to estimate subjective speech quality, which is herein referred to as end-user quality of service. End-user quality of service is an objective quality measurement with good correlation to the subjective quality as perceived by a human end-user. Such an objective measure is much more accurate from the human end-user point of view than what is called "quality of service" in the context of Dollin et al. Although the link parameters, i.e., what is regularly called "quality of service", do influence the end-user quality of service, the difference between end-user quality of service and conventional "quality of service" is evidenced by the fact that for the same set of link parameters the end-user quality of service may be different, depending on such factors as coder/decoder, terminal parameters relevant to the application, e.g., input buffer size, whereas the conventional "quality of service" would be the same. Further, a change in a link parameter may affect the end-user quality of service of a speech connection, but may not affect the end-user quality of service of a video connection, whereas for conventional "quality of service" measurements, the changing of a link parameter

would alter the conventional quality of service for both the video and speech connection. Accordingly the measurement of link parameters leads to an objective measurement of the speech quality which may or may not be an accurate indicator of the end-user quality of service.

Although Minde et al. describes the measurement of end-user quality of service in cellular networks, until now end-user quality of service has not been used in packet switched network. Further, Minde et al. fails to teach the use of end-user quality of service to identify the source of the degradation of the end-user quality of service in a packet switched network. Minde et al. also fails to teach the dynamic adaptation of a packet switched network based on end-user quality of service.

Accordingly, it would be desirable to make continuous link parameter measurements to determine the end-user quality of service in a packet switched network. Further, it would be desirable to make continuous measurements of the end-user quality of service for both individual communication connections and for the network as a whole, in a packet switched network. It would be desirable to identify the source of the degradation of the end-user quality of service in a packet switched network. It would also be desirable to use end-user quality of service measurements to make dynamic adaptations in a packet switched network in order to improve the overall network end-user quality of service.

SUMMARY OF THE INVENTION

Exemplary embodiments of the present invention provide an arrangement and method for improving end-user quality of service for a communications connection and for a network as a whole by dynamically adapting the service and/or the traffic in response to continuously measured link parameters. In order to accomplish this a method for measuring, supervising and controlling the end-user quality of the service throughout the network is described.

According to an exemplary embodiment of the present invention, link parameters and device parameters relevant to end-user quality of service are continuously measured at endpoints and other nodes in a network. The endpoints make end-user quality of service measurements. The endpoints periodically send reports to a service quality supervisor (SQS) containing end-user quality of service measurements. Depending upon the end-user quality of service measurement of the endpoint, the endpoint may also include the measured link and device parameters in the report to the SQS. Other nodes in the network send reports to the SQS regarding measured link parameters. The SQS continuously analyzes the reports and sends commands to the node and/or endpoint in order to dynamically improve the end-user quality of service at the node or endpoint and in the network as a whole.

A first objective of the present invention is to provide a more accurate and reliable measure of quality of service in packet switched networks, namely the end-user quality of service.

A second objective of the present invention is to provide an overall and more accurate, assessment of network performance based on end-user quality of service.

Yet another objective of the present invention is to maintain and/or improve the overall performance in a packet switched network as a function of the end-user quality of service measurements.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and features of the present invention will be more apparent from the following description of the preferred embodiments with reference to the accompanying drawings, wherein:

Figure 1 illustrates a packet based network according to an exemplary embodiment of the present invention;

Figure 2 illustrates the primary functions of the present invention;

Figure 3 illustrates the measuring of link and device parameters and the measurement of end-user quality of service by nodes and endpoints;

Figure 4 illustrates a method for measuring and reporting an endpoint's end-user quality of service;

Figure 5 illustrates the reception and processing of reports by the SQS;

Figure 6 illustrates a method for identification by the SQS of the cause of quality degradation;

Figure 7 illustrates communication between two packet networks through a pair of gateways;

Figure 8 illustrates an exemplary procedure for improving end-user quality of service when the degradation is caused by another network; and

Figure 9 illustrates a method for the adaptation of the endpoint's service.

DETAILED DESCRIPTION

The present invention generally involves controlling the overall performance capabilities of a packet switched network, for example, the packet switched network 100 illustrated in figure 1. The system of figure 1 comprises, among other components, terminals 101 and 102, packet switched core network 103, service quality supervisor (SQS) 104 and an associated storage medium 105. Terminal 101 and terminal 102, also referred to herein as endpoints, may communicate with each other through the packet switched core network 103, as will be discussed below. Terminals 101 and 102 may comprise telephones, computer terminals having microphones, video conferencing terminals, or any communication device capable of receiving and reproducing signals which can be percieved by human beings. The SQS 104 can be implemented as a router with high-cost links (e.g., as an open shortest path first (OSPF) router which has a built-in database of the domain topology), or in an H.323 system the SQS 104 may be implemented in a gatekeeper, i.e. the entity which provides control access to the zone. Alternatively, the SQS 104 may be implemented as a standalone device.

The SQS 104 communicates with the other network devices through the packet switched core network 103. The network may include both wireline and wireless connections and the nodes within packet switched network 100 may comprise routers, gateways, and special nodes for wireless connections (e.g., base stations). Terminal 101, terminal 102 can measure link parameters, measure device parameters, make end-user quality of service measurements and send reports regarding the measured link parameters, the measured device parameters and the end-user quality of service measurements to SQS 104.

Figure 2 illustrates three primary functions for implementing the present invention. Accordingly, in step 205 link and device parameters are continuously measured by various nodes and endpoints in the packet switched network, according to a first primary function of the present invention. In step 210, the end-user quality of service is measured at the endpoints using the measured link parameters and the measured device parameters, and at the SQS using the measured link parameters, the measured device parameters and the end-user quality of service measurements sent from various nodes and endpoints in the network. Using the measured end-user quality of service, the endpoint and/or the SQS can identify the cause of the degradation of the end-user quality of service, according to a second primary function of the present invention. In step 215, the SQS dynamically improves the end-user quality of service for both individual connections and for the entire network, in accordance with a third primary function of the present invention.

Figure 3 illustrates the collection of link parameters and device parameter measurements by routers 303-309, and endpoints 301 and 302, and the measurement of end-user quality of service by endpoint 302 in a packet switched network, in accordance with the first primary function of the present invention. According to the exemplary embodiment illustrated in figure 3, endpoint 301 is transmitting an information signal to endpoint 302 through packet core network 310, which is only part of core network 103. Although figure 3 shows endpoint

301 as a transmitter and endpoint 302 as a receiver, one skilled in the art will recognize that either endpoint can simultaneously transmit and receive information signals through packet core network 310. Depending upon the network load, the information signal may travel from endpoint 301 to router 303, from router 303 to router 305, and from router 305 to endpoint 302. Alternatively, the information signal may travel from endpoint 301 to router 303, from router 303 to router 309, from router 309 to router 305, and from router 305 to endpoint 302. The choice of path for the information signal may be controlled by the SQS in accordance with traffic adaptation commands, as described below.

While endpoint 301 is sending an information signal, the endpoint 301 is measuring device parameters, $DP_{T1}...DP_{Tn}$, and link parameters, $LP_{T1}....LP_{Tn}$. According to an exemplary embodiment of the present invention device parameters $DP_{T1}...DP_{Tn}$ may include processing and packetizing delays, codec mode, user data rate, interleaving depth and interleaving type. Link parameters $LP_{T1}....LP_{Tn}$ can include link delay or access delay. While receiving the information signal from endpoint 301, endpoint 302 is measuring link parameters, $LP_{R1}....LP_{Rn}$, device parameters $DP_{R1}.....DP_{RM}$, and making end-user quality of service measurements, EuQoS, based upon the measured link and device parameters. According to an exemplary embodiment, the link parameters $LP_{R1}....LP_{Rn}$ may include estimated bit error rate (BER) and total delay. Device parameters $DP_{R1}.....DP_{RM}$ may include buffer load, buffer status, interleaving type, decoding mode, error concealment unit, and host processing unit. During the communication between endpoints 301 and 302, routers 303-309 measure link parameters, $LP_{N1}....LP_{NR}$, and device parameters, $DP_{N1}.....DP_{NS}$. According to an exemplary embodiment of the present invention, link parameters, $LP_{N1}....LP_{NR}$, can include estimated BER, link delay, access delay, unit loss, unit corruption, burst dispersion, peak- low- and mean-bandwidth. Device parameters, $DP_{N1}.....DP_{NS}$ may include unit delay, unit delay variation, unit flush, buffer load and buffer status. Further it is noted that each node or endpoint need not measure the same number of device parameters as the

number link parameters measured by the node or endpoint. The measurement of link and device parameters and the measurement of end-user quality of service by endpoints 301 and 302 is illustrated in figure 4.

Figure 4 illustrates the creation and transmission of end-user quality of service reports, device parameter reports and link parameter reports by an endpoint such as endpoint 302, in accordance with the first primary function of the present invention. During a conversation, in step 405 an endpoint collects and measures device parameters and link parameters. In step 410 the endpoint measures the end-user quality of service based upon a statistical model, in a similar fashion as described in Minde et al., but using the link parameters and device parameters relevant to the end-user quality of service for packet switched networks. In step 415 the results of the end-user quality of service measurements are displayed to the user of the terminal. However, step 415 is optional and may be omitted. At regular intervals of time the end-user quality of service at the endpoint is reported to the SQS. Accordingly, in step 420 it is determined whether a time interval has elapsed and whether it is time to send a report. The report will always include the end-user quality of service measurement from step 410. However, if the endpoint determines that the end-user quality of service is not acceptable, then the endpoint may send an emergency report containing the end-user quality of service measurement, the measured link parameters and the measured device parameters. If the time interval has elapsed and it is time to send a report, in accordance with the "YES" path out of decision step 420, then a report is transmitted to the SQS 104 and to endpoint 301 in accordance with step 430. As will be described below in figure 5, the SQS 104 uses the report to measure both the end-user quality of service for a specific connection and the overall network end-user quality of service. The report sent to the other endpoint may contain an adapt service command, as will be described below in figure 9.

As mentioned above, the endpoint of the present invention includes an emergency report feature, wherein the endpoint will send an emergency report if

the measured end-user quality of service falls below an acceptable end-user quality of service threshold before it is time to send a regular report. Steps 420 and 425 illustrate the emergency report feature. If it is determined that the time interval has not elapsed, in accordance with the "NO" path out of decision step 420, then it is determined whether the measured end-user quality of service is less than an acceptable end-user quality of service threshold, in accordance with step 425. If the measured end-user quality of service is greater than or equal to the acceptable end-user quality of service threshold, in accordance with the "NO" path out of decision step 425, then the process returns to step 405 for the endpoint to collect link parameters and device parameters. If the measured end-user quality of service is less then the acceptable end-user quality of service threshold, in accordance with the "YES" path out of decision step 425, then a report, containing the measured link parameters, the measured device parameters and the measured end-user quality of service is transmitted to the SQS 104 and, optionally, to the other endpoint, in accordance with step 430. The end-user quality of service measurement is sent to the other endpoint in order to keep the user of the other endpoint informed about how the partner perceives the communication and adapt the service if necessary and possible, as described in figure 9 below. Similar procedures are applied at other nodes, but regarding other parameters, e.g., the traffic load for the routers and base stations.

SQS 104 has two principal tasks which correspond to the second and third primary functions of the present invention. The first principal task of the SQS involves receiving link parameters, device parameters and end-user quality of service reports, determining problems with the end-user quality of service based upon the reported end-user quality of service measurement, the link parameters, and the device parameters, and identifying the source of any such problems with the help of a traffic model. The first principal task of the SQS 104 is illustrated in figure 5 below.

The second principal task of the SQS 104 involves supervision of the packet switched network 100, which corresponds to the third primary function of the present invention, namely dynamic adaptation of the network. Supervision of the packet switched network 100, in turn, generally involves the dynamic adaptation of traffic and the dynamic adaptation of services. The dynamic adaptation of traffic may, for example, involve rerouting communications (i.e., data packets) around congested routers and/or congested gateways, limiting the real-time and/or the non real-time traffic, and joint optimization of the wireless connection with the help of a radio network access controller in case such a radio connection is used. Dynamic adaptation of service, which is only sent to endpoints in the network, includes commanding the transmitting endpoints to adjust one or more device transmission parameters (e.g., transmission bit-rate, codec type, ect) The supervision function is illustrated in figures 5-10 and described in more detail below.

Figure 5 illustrates a technique by which the SQS 104 receives and processes end-user quality of service reports, device parameter reports and link parameter reports from the various network devices, such as endpoints 101 and 102, and dynamically adapts the network in accordance with the second and third primary functions of the present invention. As shown in figure 5, the SQS 104 initially determines whether it has received a new report, in accordance with step 505. According to an exemplary embodiment, the report is issued from an endpoint in accordance with the method shown in figure 4. If it has been determined that a new report has not been received by any of the various network devices, in accordance with the "NO" path out of decision step 505, the SQS 104 continues to monitor for new reports. However, if it is determined that a new report has been received in accordance with the "YES" path out of decision step 505, then the SQS 104 analyzes the received report to identify the source, i.e., the network device that sent the report, as shown by step 510. In step 515, the received report is used by the SQS 104 to measure the end-user quality of service

using a statistical model in the same fashion as described in Minde et al. but using parameters specific to packet switched networks.

The technique illustrated in figure 5 now focuses on dynamically adapting the transmission, if it is determined that doing so is necessary to improve the end-user quality of service, in accordance with the third primary function of the present invention. Accordingly, in decision step 520, the SQS 104 determines whether the end-user quality of service as measured and reported, is less than a predetermined end-user quality of service threshold. If it is determined that the end-user quality of service is less than the predetermined end user quality of service threshold, in accordance with the "YES" path out of decision step 520, the SQS 104 generates and forwards an adapt service command to the network device that is transmitting the signals in order to change one or more device parameters related to the transmission of the signal from the source, as indicated in step 525. The implementation of the adapt service command at an endpoint is described below in greater detail with figure 9.

If the SQS 104 determines that the end-user quality of service measurement, as reported, is greater than or equal to the predetermined end user quality of service threshold, in accordance with the "NO" path out of decision step 520, or after the SQS 104 has issued an adapt service command, the SQS 104 uses the end-user quality of service measurement in the current report as well as end-user quality of service measurements in a number of previously received reports from other network devices to measure an overall end-user quality of service for the network, in accordance with step 530. It will be understood that the overall end-user quality of service for the network represents one method by which the network could be optimized. The network operator may choose to optimize the network according to different factors, such as optimization for higher paying customers. Accordingly, the SQS 104, in order to optimize the network as the network operator chooses, may derive an overall average network quality of service measurement, an average quality of service measurement for a particular

area in the network, a standard deviation from the mean overall network quality of service measurement, the average quality for a particular set of connections or any number of other alternatives.

After measuring the overall end-user quality of service for the network, the SQS 104, in decision step 535, determines whether the overall end-user quality of service for the network is less than a predetermined acceptable network quality threshold. If the SQS 104 determines that the overall network quality of service is greater than or equal to the predetermined acceptable network quality threshold, in accordance with the "NO" path out of decision step 535, then, in step 560, the measurements are used for updating the status of the traffic model. The status of the network and the relevant parameters from the report are stored in storage medium 105. Then the control returns to step 505 where the SQS 104 awaits a new report.

The network model, referred to above, is based upon the known topology of the network and has as input variables the parameters reported from the endpoints and nodes in packet switched network 100. The topology of the network and the continuously updated state of the model are stored in storage medium 105 of SQS 104, and are used for monitoring the traffic and detecting the sources of the problems in the packet switched network 100. According to a purely exemplary embodiment of the present invention, if the SQS receives a group of link parameter reports indicating unacceptable delays in the transmission of packets and that the reports are originating from nodes which are within the same general area of the network, then the SQS will have identified the source of the degradation of the network speech quality. It is understood that the SQS 104 can monitor only the packet switched network which it has supervision over, as will be described below in conjunction with figures 7 and 8.

If however, the SQS 104 determines that the overall end-user quality of service for the network is less than the predetermined acceptable network quality threshold, in accordance with the "YES" path out of decision step 535, then the

SQS 104 so informs the network operator, in accordance with step 540. After informing the network operator that the overall end-user quality of service for the network is less than the predetermined acceptable network quality threshold, the SQS 104 performs one of several SQS functions, i.e., identification and correction of the cause of the end-user quality of service degradation as indicated in step 545. After an SQS function has been performed, it is determined whether there are more SQS functions to be performed, in accordance with step 550. If it is determined that there are more SQS functions to be performed, in accordance with the "YES" path out of decision step 550, then the SQS function is performed in step 545. If it is determined that there are no more SQS functions to be performed, in accordance with the "NO" path out of decision step 550, then the state of the network model is updated in step 555. After the state of the network model is updated, the values associated with the network model state are stored in step 560.

Figure 6 illustrates a first exemplary SQS function, wherein the cause of degradation for the overall end-user quality of service for the network is identified, in accordance with the second primary function of the present invention. As described above, the SQS uses data from the reports, i.e., end-user quality of service, link parameters and device parameters to update the network model. In step 605, the SQS attempts to identify the cause of the degradation in the overall network end-user quality of service measurement using the updated network model. In step 610 it is determined if the cause of the degradation has been successfully identified. If the cause of the degradation is not successfully identified, in accordance with the "NO" path out of decision step 610, then control returns to step 550 of figure 5. However, if the cause of the degradation has been successfully identified, in accordance with the "YES" path out of decision step 610, then the SQS issues an adapt traffic command to the node or an adapt service command to the endpoint, which is causing the degradation to the overall network

end-user quality of service, as indicated in step 615, in accordance with the third primary function of the present invention.

Traffic adaptation may be accomplished according to various methods, among which are a reduce low priority load command and an adapt traffic command. The reduce low priority load command can be issued for limiting the non real-time or the low priority packets traffic, if a priority differentiation protocol is implemented in the network, such that a higher network capacity is available for the real-time service. The adapt traffic command is issued to routers so that they adapt the paths for the services. Finally, in step 620 the operator is informed of the source of the degradation and the methods which the have been implemented to rectify the degradation. After the operator is informed, the procedure returns to step 550 of figure 5 to determine whether there are more SQS function to be performed.

Figure 8 illustrates an exemplary SQS function in which the SQS corrects end-user quality of service degradation caused by another network wherein the other network is connected to the SQS through a gateway, in accordance with the second and third primary functions of the present invention. However, in order to fully appreciate figure 8, the use of gateways to connect two networks is illustrated in figure 7. Figure 7 illustrates the connection between two packet networks through a pair of gateways. The communications link 790 may comprise a public switched telephone network (PSTN), a global system for mobile communications network (GSM), or an integrated services digital network (ISDN) communications link. When terminals 710 and 760 are in communication with each other, gateways 720 and 770 perform two primary functions. The first function is to convert the communication to a format which is compatible with communications link 790. The second function is to monitor the quality of the information signals sent to the other network as well as the information signals received from the other network.

Referring now to figure 8, in step 810, the SQS 705 analyzes reports received from gateway 720 or terminal 710. In step 815, SQS 705 determines whether the end-user quality of service degradation originates outside of network 715. In order for the SQS 705 to make the aforementioned determination the network model is analyzed to determine the source of the degradation. If SQS 705 does not successfully determine that the cause of the network degradation originates outside of network 715, in accordance with the "NO" path out of decision step 815, then the process returns to step 550 in order to determine whether other SQS functions are to be performed in accordance with the network model. However, if it is successfully determined that the cause of the degradation occurs outside of network 715, in accordance with the "YES" path out of decision step 815, then SQS 705 notifies SQS 755 of the degradation of the end-user quality of service, using a command in step 820. In step 825, the operator is informed that the cause of the degradation occurred outside of network 715 and that a command has been sent to network 765. Conversely, if SQS 755 determines that a cause of degradation originates from packet network 715, then SQS 755 would inform SQS 705 of the degradation of the communication, so that SQS 705 can take corrective measures.

Figure 9 illustrates the implementation of the adapt service command described in figure 5 step 525, which is sent from the SQS 104 or from another endpoint to the source of transmission, in accordance with the third primary function of the present invention. Functionally, the adapt service command instructs the network device transmitting the information signals to adjust its transmission of the information signals, so as to effect an improvement in the end-user quality of service at the receiving network device, i.e., the network device responsible for sending the SQS 104 the present report. The command can be both restrictive, e.g., by requiring a lower bit-rate injected into the network and permissive, e.g., by allowing a higher bit-rate injected into the unloaded network. Consequently, the network device transmitting the information signals may change

the coding mode, i.e., the coding scheme employed to encode the information signals or, alternately, decrease the transmission bit rate. Accordingly, in step 905 the endpoint determines whether a command has been sent from the SQS. If the SQS has not sent a command, in accordance with the "NO" path out of decision step 905, then the endpoint determines if it has received information from the other endpoint, in accordance with step 910. The other end-user may require the change of the data rate and/or the codec and this action may be completed in the limits imposed by the last command received from the SQS. If the other endpoint has not received information from another endpoint, in accordance with the "NO" path out of decision step 910, then the process returns to step 905. However, if information has been received from the other endpoint, in accordance with the "YES" path out of decision block 910, or if a command has been received from the SQS, in accordance with the "YES" path out of decision block 905, then the service is adapted, in accordance with step 915.

Although the present invention has been described as using speech quality measurements to send commands to improve online, i.e., real-time, the speech quality, one skilled in the art will recognize that the operator can use this data, or analysis, to modify and adjust the network, e.g., add new units, change the hardware, change the infrastructure, etc., that represent off-line optimizations of the network.

In an exemplary embodiment the service quality supervisor is implemented as a software package in a server. Further, in a purely exemplary embodiment the service quality supervisor may be located in the same place where the billing functions are performed. Although the present invention has been described in with regard to the measurement and correction of information signals and speech signals, one skilled in the art will recognize that the present invention can be implemented to measure and correct any type of quality. For instance, the present invention can measure the perceived quality of a graphic file, a video clip, or an Internet web page sent over the packet switched network.

Although the present invention has been described by reference to communication between two endpoints, the present invention is equally applicable to multipoint communication, wherein more than two endpoints are communicating in a conference arrangement.

While the present invention has been described with respect to the aforedescribed exemplary embodiments, one skilled in the art will appreciate that the invention can be embodied in other ways. Thus, many variants and combinations of the techniques taught above may be devised by a person skilled in the art without departing from the spirit or scope of the invention as described by the following claims.

WHAT IS CLAIMED IS:

1. A method for improving end-user quality of service in a packet switched network comprising the steps of:

measuring, at each of a plurality of network nodes, a parameter;

measuring the end-user quality of service using said measured parameter;

dynamically adapting the network, as a function of the measured end-user quality of service to improve the end-user quality of service.

2. The method of claim 1, wherein one of said plurality of network nodes is a first endpoint and wherein a second of said plurality of nodes is a second endpoint, wherein said first and said second endpoints communicate over a connection through said packet switched network.

3. The method of claim 2, wherein said first endpoint measures said end-user quality of service for the connection.

4. The method of claim 3, wherein said first endpoint sends reports to a service quality supervisor including measured link parameters and measured device parameters and measured end-user quality of service, and wherein said service quality supervisor dynamically adapts the packet switched network in order to improve said end-user quality of service.

5. The method of claim 3, wherein said service quality supervisor sends an adapt service command to said second endpoint if said measured end-user quality of service falls below a predetermined end-user quality of service threshold.

6. The method of claim 3, wherein said first endpoint sends an adapt service command to said second endpoint if the measured end-user quality of service falls below a predetermined end-user quality of service threshold.

7. The method of claim 1 further comprising:

receiving reports, in a service quality supervisor, comprising measured link parameters, measured device parameters, and end-user quality of service measurements;

measuring an overall network end-user quality of service, in said service quality supervisor, using said reports.

8. The method of claim 7, wherein said service quality supervisor dynamically adapts the network if the overall network end-user quality of service measurement is less than a predetermined overall network end-user quality of service threshold.

9. The method of claim 8 wherein said dynamic adaptation is a command selected from a group of commands consisting of a reduce low priority load command and an adapt traffic command.

10. The method of claim 1 further comprising:

updating a network model with said measured parameters and said end-user quality of service measurements, wherein said measured parameter includes device parameters and link parameters.

11. The method of claim 10 further comprising:

identifying a cause of the end-user quality of service degradation using said network model.

12. The method of claim 10, wherein one of the plurality of network nodes is a gateway between said packet switched network and another packet switched network; and

wherein said cause of said end-user quality of service degradation is the another packet switched network.

13. The method of claim 13, further comprising the step of:

sending an adapt traffic command to a service quality supervisor located in said second packet switched network.

14. An arrangement for improving end-user quality of service in a packet switched network comprising:

a first endpoint;

a second endpoint which communicates with the first endpoint through the packet switched network;

a service quality supervisor which measures the end-user quality of service using reports sent from network nodes.

15. The arrangement of claim 14, wherein the network nodes comprise said first and said second endpoints.

16. The arrangement of claim 15, wherein said reports comprise link parameters measurements, device parameters measurements and endpoint end-user quality of service measurements.

17. The arrangement of claim 15, wherein said network nodes further comprise a router.

18. The arrangement of claim 17, wherein said measured end-user quality of service is an overall network end-user quality of service based upon said reports from said network nodes.

19. The arrangement of claim 18, wherein said service quality supervisor updates a network model using said reports.

20. The arrangement of claim 19 wherein said service quality supervisor identifies a source of end-user quality of service degradation using said network model.

21. The arrangement of claim 14, wherein said service quality supervisor measures the end-user quality of service for said first endpoint using reports sent from said first endpoint.

22. The arrangement of claim 15, wherein said first endpoint measures link parameters, measures device parameters and measures a end-user quality of service for the communication with the second endpoint based on said link parameters.

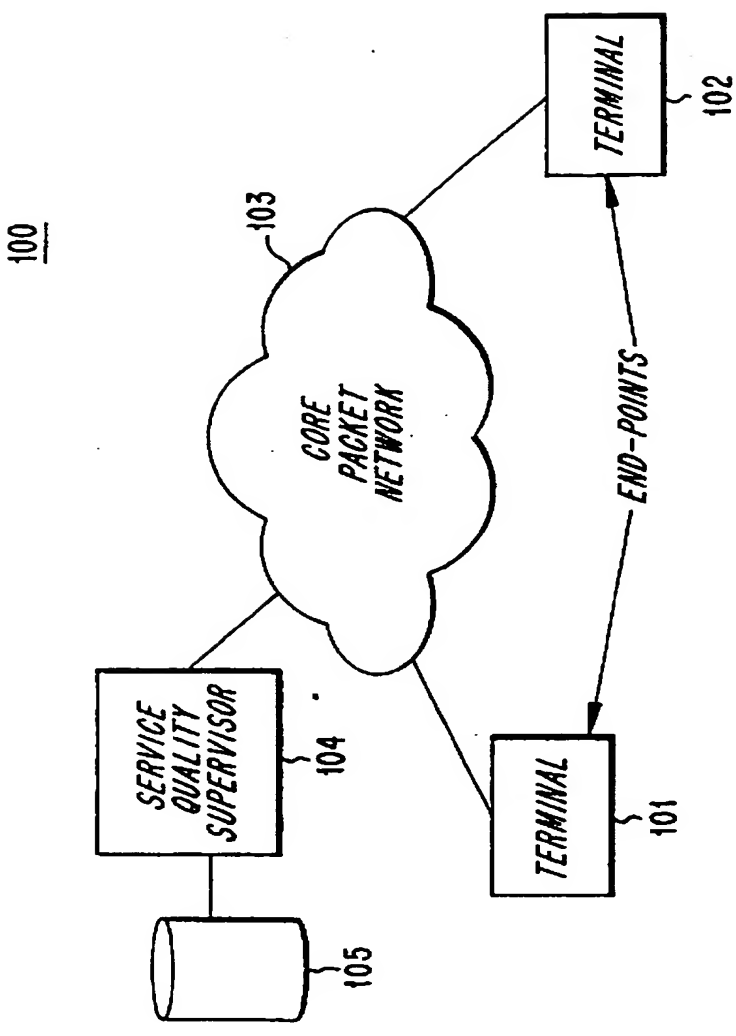

100
103
CORE PACKET NETWORK
TERMINAL
102
END-POINTS
SERVICE QUALITY SUPERVISOR
104
TERMINAL
101
105

FIG. 1

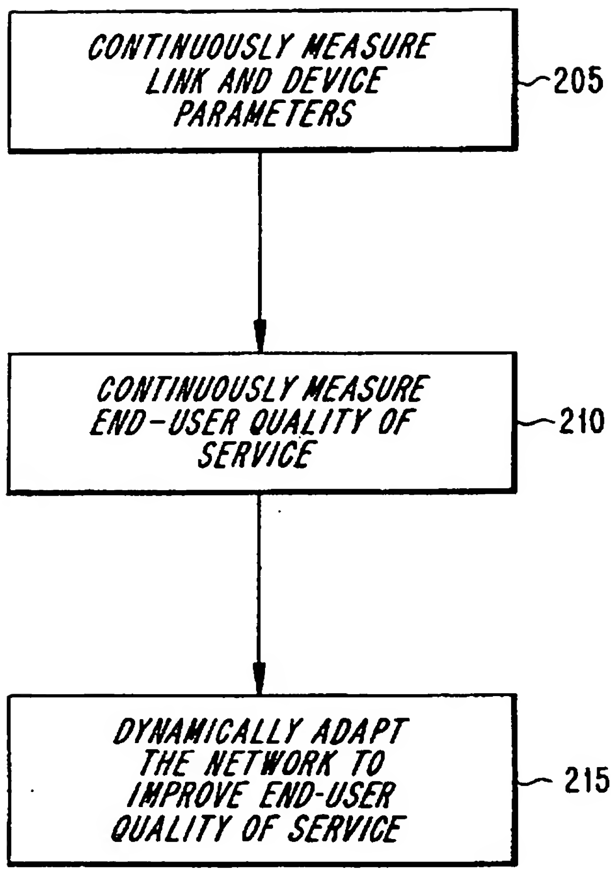

CONTINUOUSLY MEASURE LINK AND DEVICE PARAMETERS
205
CONTINUOUSLY MEASURE END-USER QUALITY OF SERVICE
210
DYNAMICALLY ADAPT THE NETWORK TO IMPROVE END-USER QUALITY OF SERVICE
215

FIG. 2

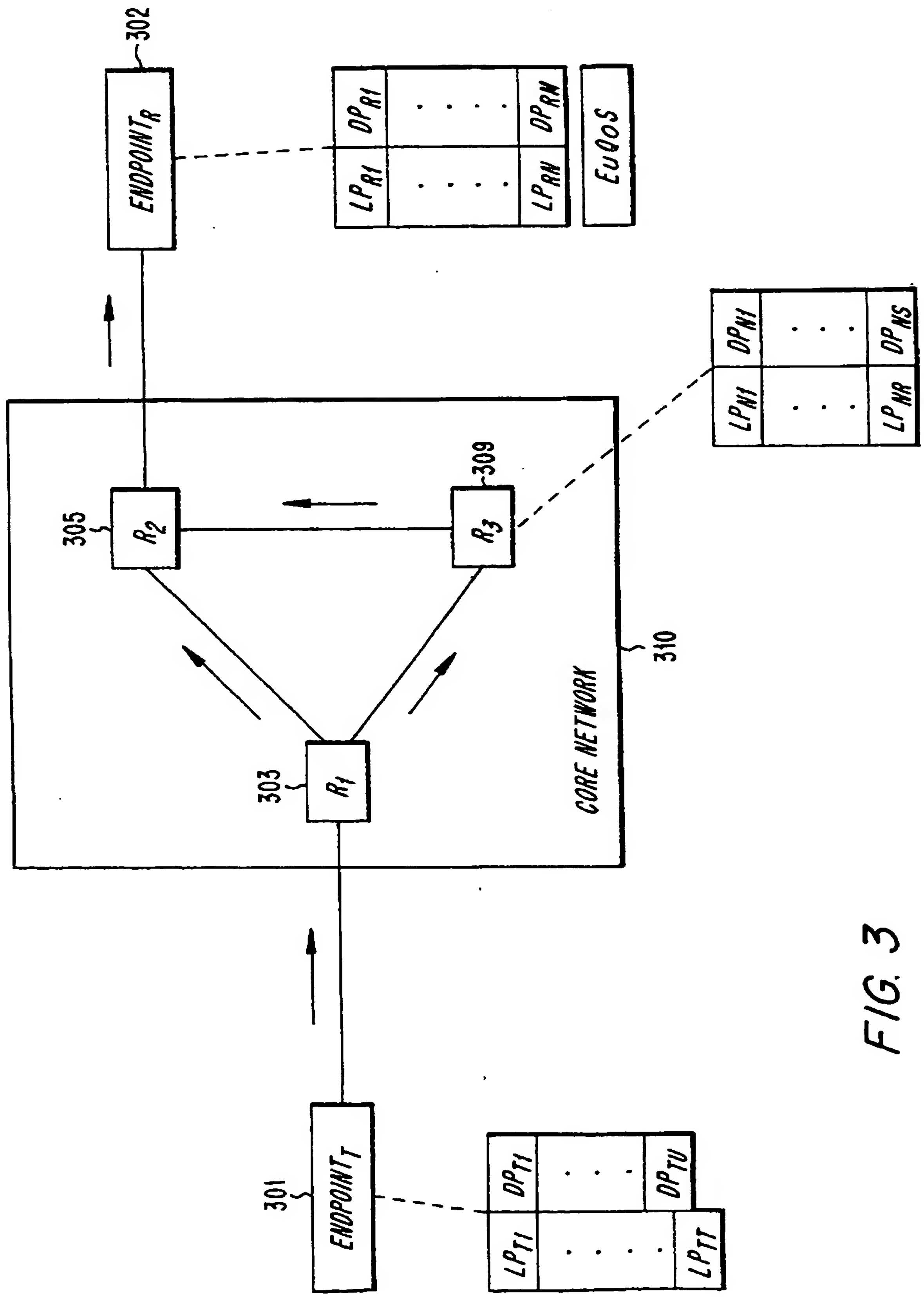

302
ENDPOINT_R
DP_R1
DP_RN
LP_R1
LP_RN
EuQoS
DP_N1
DP_NS
LP_N1
LP_NR
305
R_2
309
R_3
303
R_1
CORE NETWORK
310
301
ENDPOINT_T
DP_T1
DP_TU
LP_T1
LP_TT

FIG. 3

FIG. 4

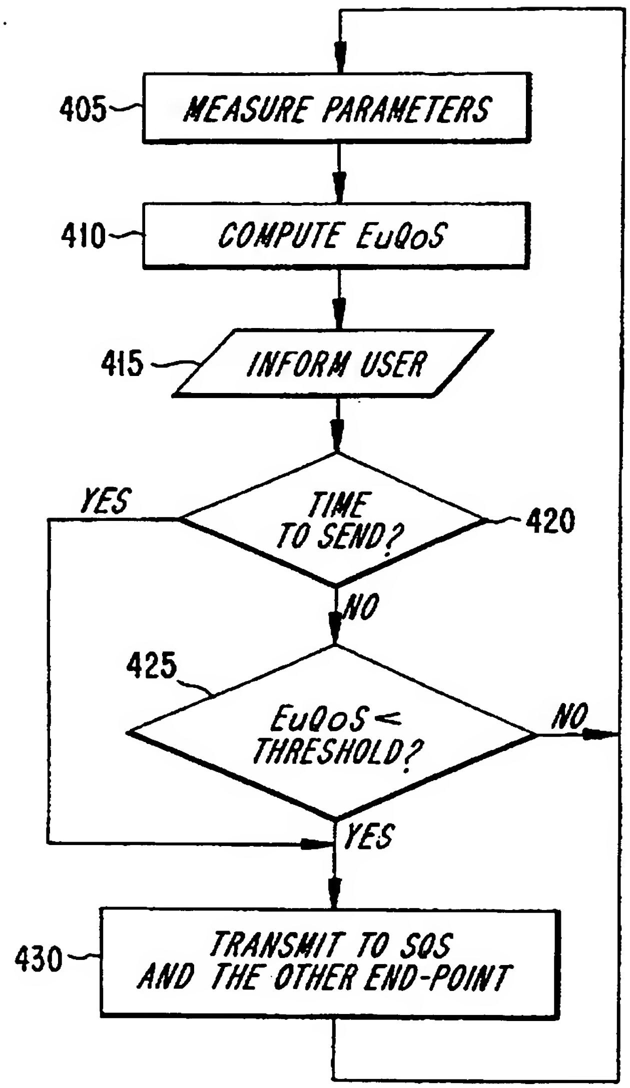
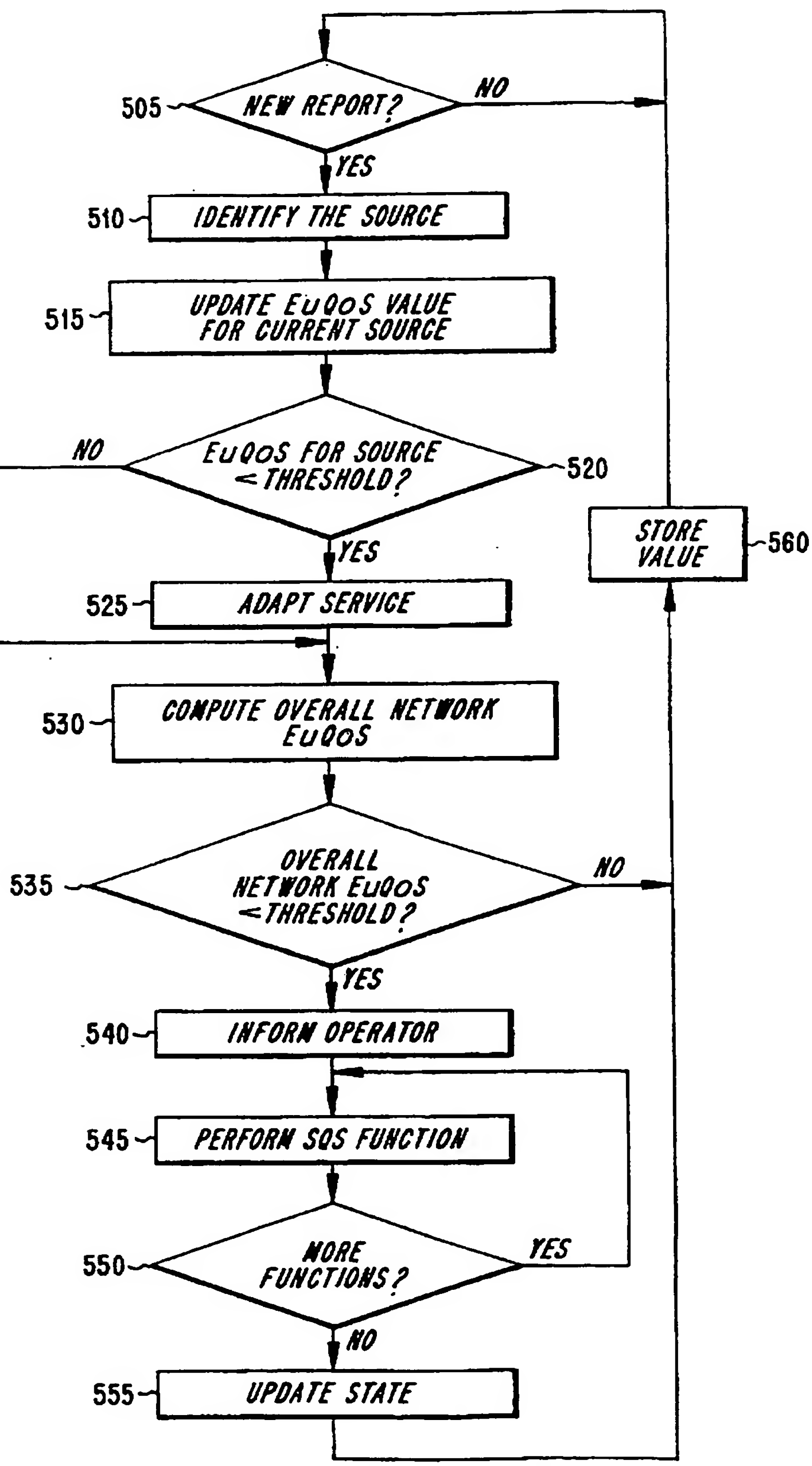

405
MEASURE PARAMETERS
410
COMPUTE EuQoS
415
INFORM USER
TIME TO SEND?
420
YES
NO
425
EuQoS < THRESHOLD?
NO
YES
430
TRANSMIT TO SQS AND THE OTHER END-POINT

FIG. 5


NEW REPORT?
505
NO
YES
IDENTIFY THE SOURCE
510
UPDATE EuQoS VALUE FOR CURRENT SOURCE
515
EuQoS FOR SOURCE < THRESHOLD?
520
NO
YES
ADAPT SERVICE
525
STORE VALUE
560
COMPUTE OVERALL NETWORK EuQoS
530
OVERALL NETWORK EuQoS < THRESHOLD?
535
NO
YES
INFORM OPERATOR
540
PERFORM SOS FUNCTION
545
MORE FUNCTIONS?
550
YES
NO
UPDATE STATE
555

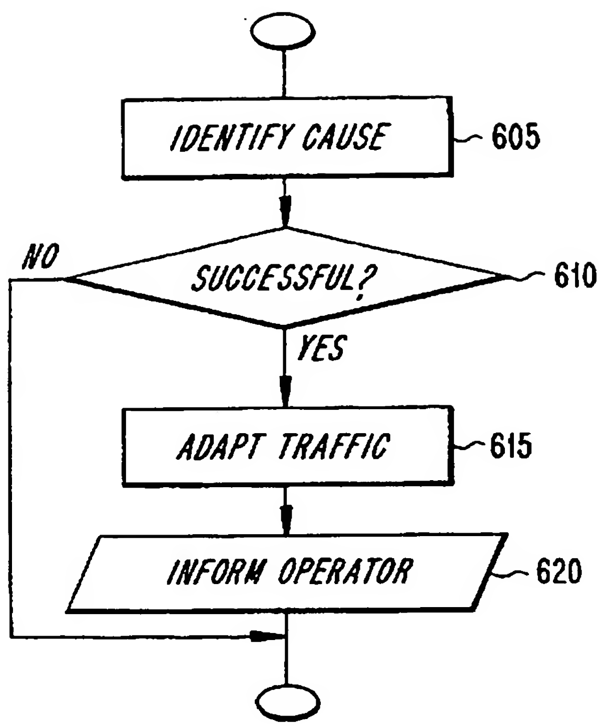

IDENTIFY CAUSE
605
SUCCESSFUL?
610
NO
YES
ADAPT TRAFFIC
615
INFORM OPERATOR
620

FIG. 6

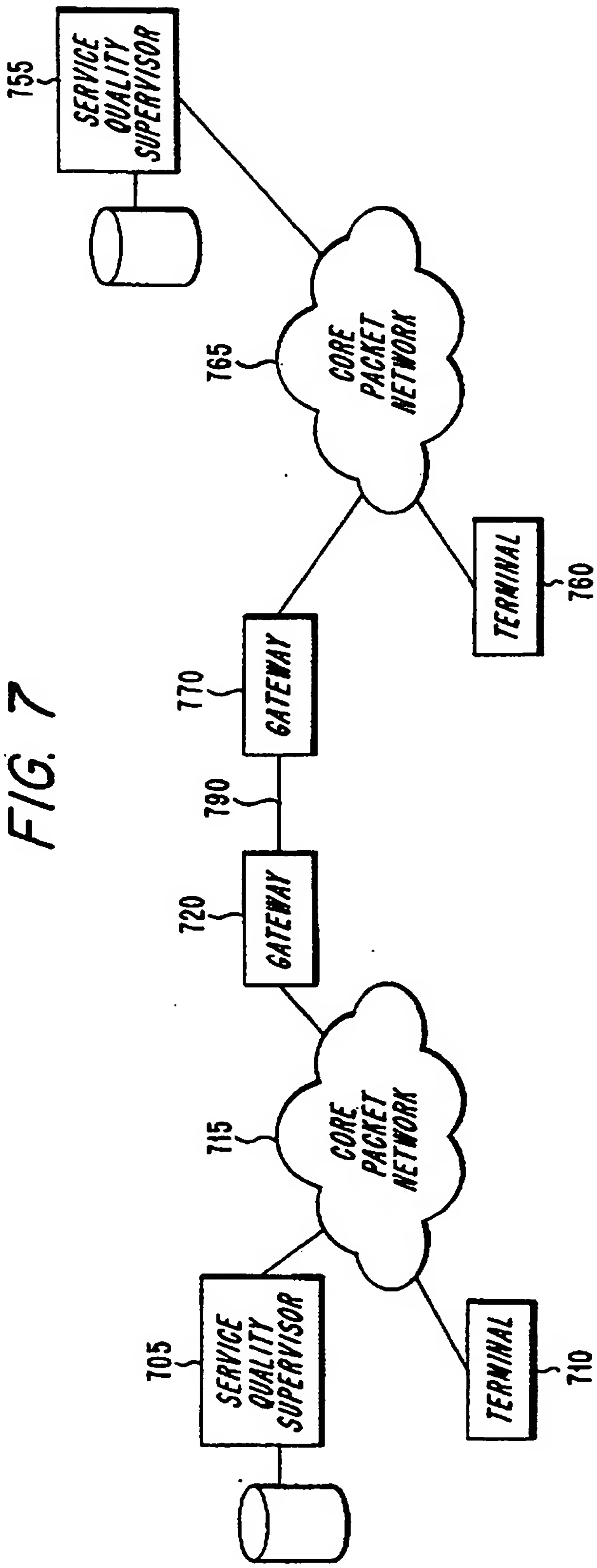

755
SERVICE QUALITY SUPERVISOR
765
CORE PACKET NETWORK
TERMINAL
760
770
GATEWAY
790
720
GATEWAY
715
CORE PACKET NETWORK
705
SERVICE QUALITY SUPERVISOR
TERMINAL
710

FIG. 7

FIG. 8

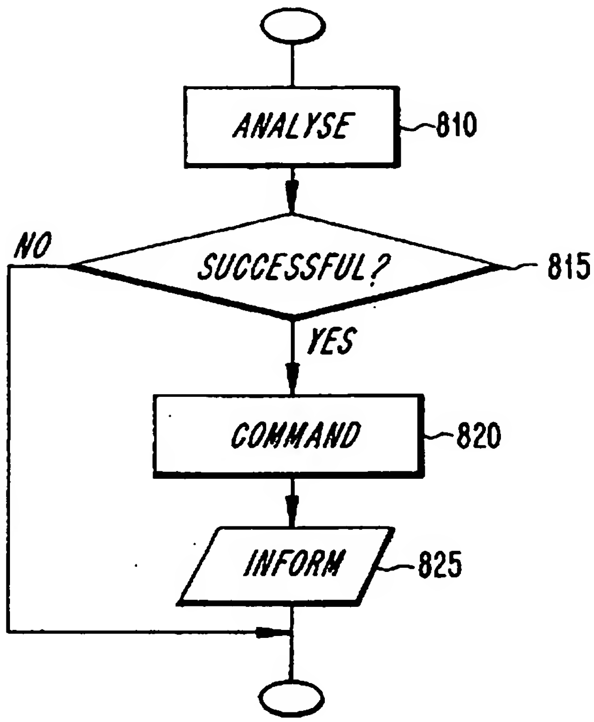
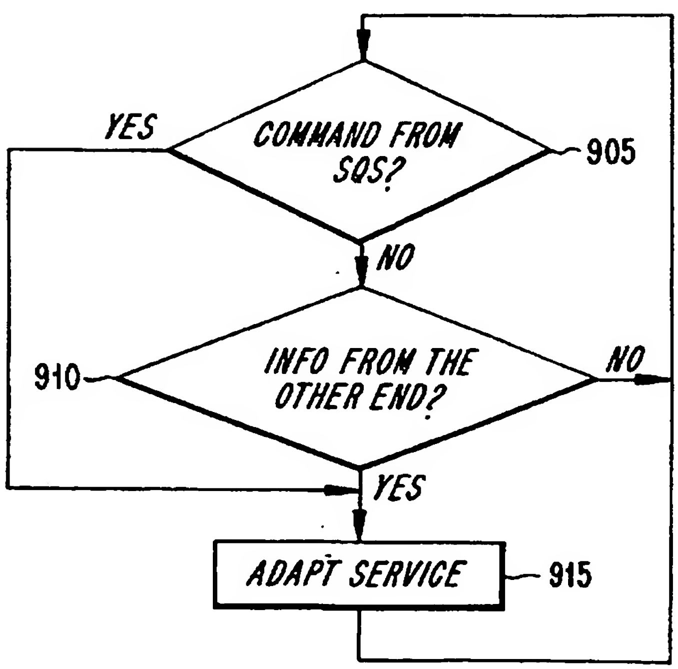

ANALYSE
810
NO
SUCCESSFUL?
815
YES
COMMAND
820
INFORM
825

FIG. 9


YES
COMMAND FROM SQS?
905
NO
910
INFO FROM THE OTHER END?
NO
YES
ADAPT SERVICE
915

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 99/02133

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NAHRSTEDT K ET AL: "DESIGN, IMPLEMENTATION, AND EXPERIENCES OF THE OMEGA END-POINT ARCHITECTURE" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS, vol. 14, no. 7, 1 September 1996 (1996-09-01), pages 1263-1279, XP000626276 the whole document	1-3,6, 10,11
A		4,5,7-9, 12-22
X	ONOE Y ET AL: "Media scaling applied to multicast communications" COMPUTER COMMUNICATIONS, vol. 21, no. 14, 15 September 1998 (1998-09-15), page 1226-1243 XP004146583 the whole document	1-3
A		4-22
A	LAKSHMAN K ET AL: "Integrated CPU and network-I/O QoS management in an endsystem" COMPUTER COMMUNICATIONS, vol. 21, no. 4, 10 April 1998 (1998-04-10), page 325-333 XP004115275 the whole document	1,14
A	TSCHICHHOLZ M: "INTEGRIERTES MANAGEMENT OFFENER TELEDIENSTE" IT + TI INFORMATIONSTECHNIK UND TECHNISCHE INFORMATIK, vol. 38, no. 6, 1 December 1996 (1996-12-01), pages 17-23, XP000637348 figures 1,2 page 17, left-hand column, line 1 -page 20, right-hand column, line 14	1,14

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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/SE 99/02133

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L12/24 H04L12/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BOUTABA R ET AL: "AN ARCHITECTURAL APPROACH FOR INTEGRATED NETWORK AND SYSTEMS MANAGEMENT" COMPUTER COMMUNICATIONS REVIEW, vol. 25, no. 5, 1 October 1995 (1995-10-01), pages 13-38, XP000539282 the whole document ---	1-22

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[X] Further documents are listed in the continuation of box C.

[ ] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 April 2000	17/04/2000

Name and mailing address of the ISA	Authorized officer
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